

THE CLAIMS

What is claimed is:

1. An apparatus for performing a specific binding assay, the apparatus comprising:
a composite waveguide comprising:
a substrate comprising a first optical material of refractive index n_1 and having a first planar surface and an opposite second surface separated by a thickness and a surrounding edge, and
a waveguide film comprising a second optical material having a refractive index n_2 which is greater than n_1 , said waveguide film disposed on said first planar surface of said substrate;
capture molecules, associated with said waveguide film, for interacting selectively with at least one type of selected analyte molecule;
a light source operably disposed to direct a light beam into said composite waveguide for propagation by total internal reflection therein;
a light detection device positioned in a cone of collection angles, said cone of collection angles having an axis oriented substantially orthogonal to a plane of said waveguide film.
2. The apparatus of claim 1, wherein said light detection device is positioned to detect light passing through said second surface of said composite waveguide.
3. The apparatus of claim 1, further comprising an optical coupling element.
4. The apparatus of claim 3, wherein said optical coupling element comprises at least one prism that focuses light into said waveguide film.
5. The apparatus of claim 3, wherein said optical coupling element comprises a diffraction grating that diffracts light into said waveguide film.

6. The apparatus of claim 5, wherein said diffraction grating is formed into said waveguide film at an upper surface thereof, opposite said first planar surface of said substrate.

7. The apparatus of claim 5, wherein said diffraction grating is formed into at least one of said first planar surface of said substrate and a surface of said waveguide film adjacent to said first planar surface.

8. The apparatus of claim 3, wherein said optical coupling element comprises a waveguide coupler that directs light into said waveguide film by evanescent coupling.

9. The apparatus of claim 8, wherein said waveguide coupler further comprises an input waveguide and a precise spacing layer to evanescently couple light into said waveguide film across said precise spacing layer.

10. The apparatus of claim 9, wherein said waveguide coupler is disposed on an upper surface of said waveguide film, opposite said first planar surface of said substrate.

11. The apparatus of claim 9, wherein said input waveguide comprises an optical material having a refractive index n_3 and has a thickness of between about 0.5 mm and about 5 mm.

12. The apparatus of claim 11, wherein said spacing layer comprises an optical material having a refractive index n_4 , where $n_4 < n_2$ and $n_4 < n_3$, said spacing layer having a thickness selected to optimize evanescent coupling of light from said input waveguide into said waveguide film.

13. The apparatus of claim 1, wherein said substrate has a thickness of at least about 10 μm .

14. The apparatus of claim 1, wherein said waveguide film has a thickness of at least about 0.1 μm .

15. The apparatus of claim 1, wherein said first optical material comprises at least one of silicon dioxide, quartz, fused silica, silicon oxynitride, and magnesium fluoride.

16. The apparatus of claim 1, wherein said second optical material comprises at least one of silicon oxynitride and silicon dioxide.

17. The apparatus of claim 1, wherein said light source comprises a laser.

18. The apparatus of claim 1, wherein said light detector comprises a charge-coupled device.

19. The apparatus of claim 1, wherein said composite waveguide further comprises a sample reservoir configured to contain a sample solution adjacent to a surface of said waveguide film.

20. The apparatus of claim 19, wherein said sample reservoir contains a sample solution comprising a plurality of molecules of a selected analyte, and a plurality of tracer molecules, said tracer molecules being activated by evanescent light escaping from said waveguide film into said sample.

21. The apparatus of claim 1, wherein said capture molecules are of a plurality of different types.

22. The apparatus of claim 21, wherein different types of said capture molecules are positioned at discrete locations from one another on a surface of said waveguide film.

23. The apparatus of claim 22, wherein said discrete locations are arranged in an array.

24. The apparatus of claim 21, wherein said different types of capture molecules are capable of reacting with at least two different analytes.

25. The apparatus of claim 21, wherein said different types of capture molecules are capable of reacting with at least four different analytes.

26. An apparatus for performing specific binding assays, the apparatus comprising:
a light source providing light of a first wavelength;
a composite waveguide comprising a substrate having a first planar surface and an opposite second surface, said substrate comprising a first optical material of refractive index n_1 , and a waveguide film disposed on said first planar surface, said waveguide film comprising a second optical material of refractive index n_2 and including a first surface with a plurality of capture molecules secured thereto, each capture molecule of said plurality of capture molecules having a binding site which selectively binds a corresponding, selected analyte, said waveguide film also including a second surface adjacent to said first planar surface of said substrate;
a light detector positioned to detect light of a second wavelength emitted through at least said waveguide film, said first and second wavelengths differing from one another.

27. The apparatus of claim 26, wherein said light detector is positioned to detect light of said second wavelength passing through said waveguide film and said substrate.

28. The apparatus of claim 26, further comprising a plate for at least partially supporting said substrate.

29. The apparatus of claim 28, wherein said plate includes at least one window formed therethrough.

30. The apparatus of claim 29, wherein said light detector is positioned to detect light of second said wavelength emitted through said window.

31. The apparatus of claim 26, wherein said light detector is positioned in a cone of collection angles having an axis oriented substantially orthogonal to said first surface of said waveguide film.

32. The apparatus of claim 26, wherein said waveguide film has a thickness of at least about 0.1 μm .

33. The apparatus of claim 26, further comprising an optical coupling element for directing said light of said first wavelength into said waveguide film.

34. The apparatus of claim 33, wherein said optical coupling element comprises at least one prism that focuses light into said waveguide film.

35. The apparatus of claim 33, wherein said optical coupling element comprises a diffraction grating that diffracts light into said waveguide film.

36. The apparatus of claim 35, wherein said diffraction grating is formed into said first surface of said waveguide film.

37. The apparatus of claim 35, wherein said diffraction grating is formed into at least one of said first planar surface of said substrate and said second surface of said waveguide film.

38. The apparatus of claim 33, wherein said optical coupling element comprises a waveguide coupler that directs light into said waveguide film by evanescent coupling.

39. The apparatus of claim 38, wherein said waveguide coupler includes an input waveguide and a precise spacing layer to evanescently couple light into said waveguide film across said precise spacing layer.

40. The apparatus of claim 39, wherein said waveguide coupler is positioned on said first surface of said waveguide film.

41. The apparatus of claim 39, wherein said input waveguide comprises an optical material having a refractive index n_3 and has a thickness of between about 0.5 mm and about 5 mm.

42. The apparatus of claim 41, wherein said spacing layer comprises an optical material having a refractive index n_4 , where $n_4 < n_2$ and $n_4 < n_3$, and said spacing layer has a thickness selected to optimize evanescent coupling of light from said input waveguide into said waveguide film.

43. The apparatus of claim 26, wherein said first optical material comprises at least one of silicon dioxide, quartz, fused silica, silicon oxynitride, and magnesium fluoride.

44. The apparatus of claim 26, wherein said second optical material comprises at least one of silicon oxynitride and silicon dioxide.

45. The apparatus of claim 26, wherein said light source comprises a laser.

46. The apparatus of claim 26, wherein said light detector comprises a charge-coupled device.

47. The apparatus of claim 26, wherein said capture molecules are of a plurality of different types.

48. The apparatus of claim 47, wherein different types of said capture molecules are positioned at discrete locations from one another on a surface of said waveguide film.

49. The apparatus of claim 48, wherein said discrete locations are arranged in an array.

50. The apparatus of claim 47, wherein said different types of capture molecules are capable of reacting with at least two different analytes.

51. The apparatus of claim 47, wherein said different types of capture molecules are capable of reacting with at least four different analytes.

52. A composite waveguide comprising:
a substrate comprising a first optical material of refractive index n_1 and having a first planar surface and an opposite second surface separated by a thickness and a surrounding edge;
a waveguide film comprising a second optical material having a refractive index n_2 which is greater than n_1 , said waveguide film disposed on said first planar surface of said substrate; and
capture molecules associated with said waveguide film and arranged in a plurality of discrete reaction sites on a surface thereof, each of said capture molecules capable of interacting selectively with at least one type of selected analyte molecule.

53. The composite waveguide of claim 52, wherein said capture molecules comprise capture molecules capable of interacting selectively with different types of selected analyte molecules.

54. The composite waveguide of claim 52, wherein said discrete reaction sites are arranged in an array on said surface of said waveguide film.

55. The composite waveguide of claim 54, wherein at least one of said discrete reaction sites comprises capture molecules that are specific for a different selected analyte than the selected analyte for which capture molecules of at least another of said discrete reaction sites are specific.

56. A method for performing a specific binding assay, the method comprising:
providing a composite waveguide comprising a substrate, a waveguide film secured to said substrate, and a plurality of capture molecules on a surface of said waveguide film, opposite said substrate;
exposing said capture molecules to a solution including a sample that may comprise molecules of at least one selected analyte;
adding tracer molecules to said solution, each tracer molecule including a site capable of binding with at least a portion of a complementary capture molecule or at least a portion of said analyte, each tracer molecule including a component that emits fluorescent radiation of an emission wavelength when exposed to radiation of an excitation wavelength;
introducing light of said excitation wavelength into said waveguide film; and
detecting light of said emission wavelength passing through said substrate.

57. The method according to claim 56, further comprising:
determining an amount of said at least one selected analyte based on said detecting.

58. The method according to claim 57, wherein said determining comprises determining amounts of a plurality of selected analytes based on said detecting.

59. The method according to claim 56, wherein said providing said composite waveguide comprises providing a composite waveguide with said substrate comprising a first optical material of refractive index n_1 and said waveguide film comprising a second optical material of refractive index n_2 .

60. The method according to claim 59, wherein said providing said composite waveguide comprises providing a composite waveguide with said refractive index n_2 of said waveguide film being greater than said refractive index n_1 of said substrate.

61. The method according to claim 56, wherein said detecting comprises positioning a light detector within a cone of collection angles having an axis oriented substantially orthogonal to a plane of said waveguide film.

62. The method according to claim 56, wherein said providing said composite waveguide comprises providing said composite waveguide with said capture molecules arranged in an array of reaction sites.

63. The method according to claim 62, wherein said providing said composite waveguide comprises providing said composite waveguide with capture molecules of at least one reaction site of said array having specificity for a different analyte than another selected analyte for which capture molecules of at least another reaction site have specificity.